

RESEARCH ARTICLE

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Terpenes From the Root of *Salvia hypoleuca* Benth

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Abstract

Background: The genus *Salvia*, with nearly 900 species, is one of the largest members of Lamiaceae family. In the Flora of Iran, the genus *Salvia* is represented by 58 species of which 17 species are endemic. *Salvia hypoleuca* Benth., is one of these species growing wildy in northern and central parts of Iran. *Salvia* species are well known in folk medicine and widely used for therapeutic purposes. Literature review shows that there is no report on phytochemical investigation of the roots of *S. hypoleuca*.

Results: The separation and purification process were carried out using various chromatographic methods. Structural elucidation was on the basis of NMR and MS data, in comparison with those reported in the literature. The isolated compounds were identified as sitosterol oleate (1), β -sitosterol (2), stigmasterol (3), manool (4), 7 α -acetoxy royleanone (5), ursolic acid (6), oleanolic acid (7), 3-epicorosolic acid (8), 3-epimaslinic acid (9) and coleonolic acid (10).

Conclusions: In the present study, three sterols, two diterpenes and five triterpenes were isolated from the ethyl acetate extract of the roots of *S. hypoleuca*. As the chemotaxonomic significance, some of the isolated compounds (1–7, 9) have not been previously reported from the species *S. hypoleuca*, while the triterpenes 8 and 10 are now documented from *Salvia* genus for the first time.

Keywords: *Salvia hypoleuca*, Coleonolic acid, 7 α -acetoxyroyleanone, 3-epimaslinic acid, 3-epicorosolic acid, Manool

Background

The genus *Salvia* L. (Lamiaceae), with more than 900 species throughout the world, is represented 58 species in Iran, 17 of which are endemic. Most of the species are used as herbal tea and flavoring agent by people and also used in traditional medicine as tonic, anti-rheumatoid, antimicrobial and carminative [1-3]. *Flora Orientalis* includes as many as 107 species of *Salvia* [4]. *Salvia hypoleuca* Benth., is one of these species which growing wildy in northern and central parts of Iran [1].

Literature review show that various secondary metabolites such as terpenoids, phenolic acids [5], polyphenols, flavonoids [3,6] and anthocyanins [7] have been reported from *Salvia* species. Limonene, α -pinene, β -pinene, 1,8-cineol, bicyclogermacrene, caryophyllene oxide and α -gurjunene are the main

components of the essential oils of various species of *Salvia* growing wildy in Iran [8-11]. In the literature, there are several reports on phytochemical investigation of the above mentioned species.

Several sesterterpene lactones, isomeric epoxides, monolactone and hypoleuonic acid have been reported from various fractions of *S. hypoleuca* [12-14]. The main aromatic components of the essential oil of *S. hypoleuca* roots have been identified as hexadecanoic acid (27.4%) and viridiflorol (14.9%) [15], while germacrene D (15.1%) and β -caryophyllene (22.0%) identified as the major constituents during flowering stages [16]. A great number of diterpenes exhibited interesting biological activities e.g. anti-tuberculous, antitumour, antibacterial, antileishmanial and antispasmodic, and *Salvia* species are the excellent source of diterpenoids [17]. In this study, we aim to report the isolation and identification of some sterols, diterpenoids and triterpenoids from the root extract of *S. hypoleuca* which have not been previously reported from this species.

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Methods

Instruments and materials

^1H -NMR and ^{13}C -NMR spectra were recorded on a Bruker Avance 500 DRX spectrometer[®] with tetramethylsilane as an internal standard and chemical shifts are given in δ (ppm). Multiple-pulse experiments (HSQC, HMBC and H-H COSY) were performed using the standard Bruker[®] programs. Silicagel 60 F₂₅₄ and Silicagel 60 RP-18 F₂₅₄S pre-coated plates (Merck[®]) were used for TLC. The spots were detected by spraying with anisaldehyde-H₂SO₄ reagent followed by heating.

Plant materials

The roots of *Salvia hypoleuca* Benth., were collected from Tehran province (near to Damavand city), Iran, at flowering stage in August 2008 and dried at room temperature. Voucher specimen was deposited at the Herbarium of Complex of Academic Center for Educational and Cultural Research under number ACECR-266.

Extraction and isolation process

Dried roots of *S. hypoleuca* (900 g) were cut into small pieces and extracted with ethyl acetate at room

temperature by percolation method for 72 hours and 3 times. The solvent was evaporated by rotary evaporator. The ethyl acetate extract (2 g) was fractionated by silica gel column chromatography (CC) with hexane, hexane: chloroform (9:1, 5:5), ethyl acetate and methanol, to give seven fractions (A-G). Fraction A (88 mg) was subjected to silica gel CC with hexane: ethyl acetate (19:1) to obtain compound 1 (21 mg). Fraction B (200 mg) was submitted to silica gel CC with hexane: ethyl acetate (9:1) to give compound 2 and 3 (17 and 13 mg respectively). Fraction C (134 mg) was submitted to silica gel CC with hexane: ethyl acetate (19:1) to result in six fractions (C₁-C₆). Fraction C₅ (14 mg) was chromatographed on silica gel CC with chloroform: ethyl acetate (19:1) to yield compound 4 (8 mg). Fraction D (126 mg) was fractionated on silica gel CC with hexane: ethyl acetate (19:1) to obtain six parts (D₁-D₆). Fraction D₃ (27 mg) was separated on sephadex LH₂₀ with methanol: ethyl acetate (7:3) to gain four fractions (D₃₁-D₃₄). Fraction D₃₃ (10 mg) was subjected to reverse phase (RP) silica gel CC with methanol: water (8:2) to result in compound 5 (5 mg). Fraction F (624 mg) was fractionated on silica gel CC with chloroform: methanol (19:1) to yield three parts (F₁-F₃). Fraction F₁ (204 mg)

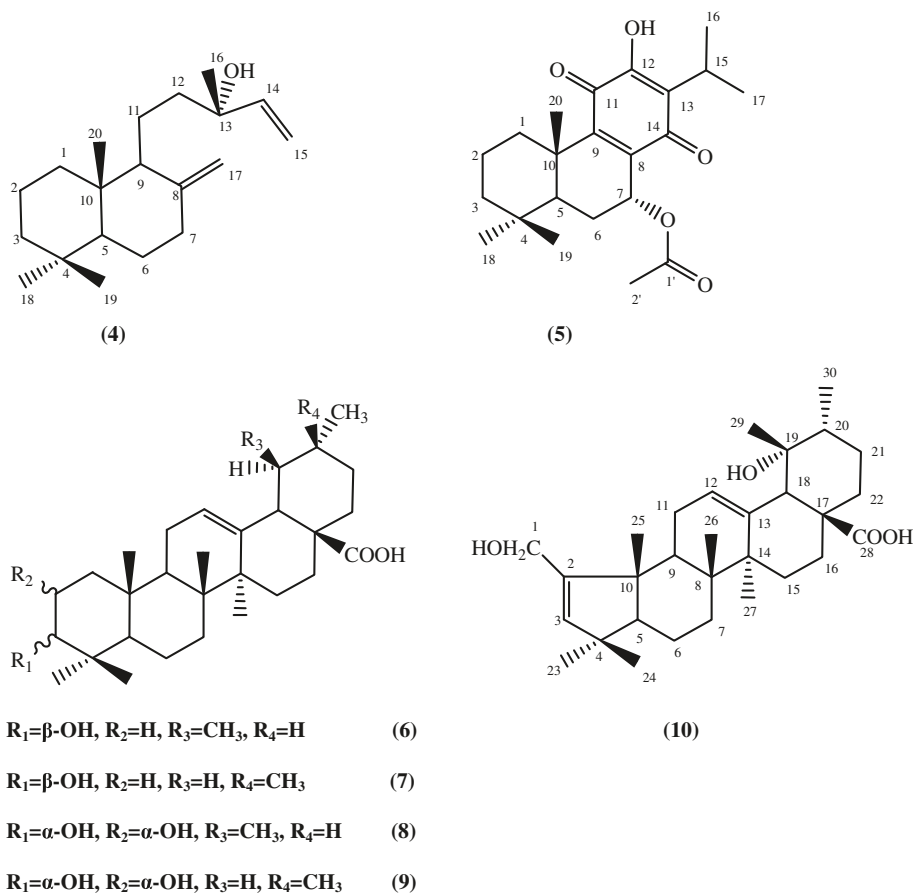


Figure 1 Structures of the isolated terpenes from the root of *Salvia hypoleuca*.

Table 1 NMR data of the compound 4 in CDCl₃

Carbon Number	DEPT	HSQC		HMBC	H-HCOSY
		¹ H-NMR δ(ppm)	¹³ C-NMR δ(ppm)		
1	CH ₂	1.00 (m, 1H)	39.07	C-5	H-1b, H-1a
		1.76 (m, 1H)			
2	CH ₂	1.36 (m, 1H)	17.70		H-2b, H-2a
		1.55 (m, 1H)			
3	CH ₂	1.17 (m, 1H)	42.19	C-4, C-5, C-18	H-3b, H-3a
		1.36 (m, 1H)		C-2	
4	C	-	33.16		-
5	CH	1.08 (brd, J=12.3 Hz, 1H)	55.58	C-4, C-6, C-7, C-18, C-20	-
6	CH ₂	1.76 (m, 2H)	24.42		-
7	CH ₂	1.95 (m, 1H)	38.35	C-6, C-8, C-17	-
		2.37 (brd, J=12.4 Hz, 1H)		C-5, C-6, C-8, C-9, C-17	
8	C	-	148.69		-
9	CH	1.55 (m, 1H)	57.32	C-8, C-10, C-17	-
10	C	-	39.87		-
11	CH ₂	1.48 (m, 1H)	19.38	-	H-11b, H-11a
		1.55 (m, 1H)		C-9, C-10, C-12	
12	CH ₂	1.27 (m, 1H)	41.43	C-16	H-12b, H-12a
		1.76 (m, 1H)		C-13, C-14	
13	C	-	73.58		-
14	CH	5.92 (dd, J=17.3, 10.7 Hz, 1H)	145.29	C-13	H-15
15	CH ₂	5.04 (d, J=10.6 Hz, 1H)	111.52	C-13	H-14
		5.20 (d, J=17.3 Hz, 1H)		C-13, C-14	
16	CH ₃	1.27 (s, 3H)	27.66	C-12, C-14	-
17	CH ₂	4.51 (s, 1H)	106.45	C-7, C-8, C-9	-
		4.81 (s, 1H)		C-7, C-9	
18	CH ₃	0.79 (s, 3H)	21.71	C-3, C-4, C-5	-
19	CH ₃	0.86 (s, 3H)	33.62	C-3, C-4, C-5, C-18	-
20	CH ₃	0.67 (s, 3H)	14.43	C-9	-

was chromatographed on silica gel CC with chloroform: ethyl acetate (8:2) to obtain nine fractions (F₁₁-F₁₉). Fraction F₁₃ (30 mg) was subjected to sephadex LH₂₀ with methanol to result in compound 6 and 7 (7 and 5 mg, respectively). Fraction F₁₇ (8 mg) was submitted to sephadex LH₂₀ with methanol to obtain compound 8 and 9 (3 and 2 mg, respectively). Fraction F₂ (67 mg) was further isolated on RP silica gel CC with methanol: water (9:1) to give compound 10 (2 mg).

Results

In the present study, the ethyl acetate extract of the root of *S. hypoleuca* was used for the isolation process and structural elucidation was carried out based on spectral data. Three sterols, sitosterol oleate (1) [18], β-sitosterol (2) [19] and stigmasterol (3) [20], two diterpenes, manool (4) [21] and 7α-acetoxyroyleanone (5) [22] together with five triterpenes, ursolic acid (6) [19], oleanolic acid (7) [23], 3-epicorolic acid (8) [24], 3-epimaslinic acid

(9) [25] and coleonic acid (10) [26], (Figure 1) were isolated and identified by comparison of their spectral data (¹H-NMR, ¹³C-NMR, HMBC, HSQC, ¹H-¹H COSY, EI-MS) with those reported in the literature. Because these compounds were previously published from other plant sources, we do not explain the spectral assignments here. NMR data (¹H-NMR, ¹³C-NMR, HMBC, HSQC and DEPT) of the compound 4 and 5 in CDCl₃ are shown in Tables 1 and 2 respectively. ¹³C-NMR data of the compounds 6–10 are indicated in Table 3. Also, HMBC correlations and important assignments of the compounds 4 and 5 (H→C) are appeared in Figure 2.

The mass data of the compounds 1, 2, 3, 6 and 7 have been previously reported [27,28]. The mass of other compounds are followed: Manool (4): EIMS (70eV) *m/z*: 290 [M]⁺ (8), 272 (40), 204 (20), 257 (58), 189 (28), 137 (100), 121 (48), 95 (67). 3-epicorolic acid (8): 472 [M]⁺ (5), 248 (100), 223 (18), 203 (61), 189 (13), 133 (20), 119 (10). 3-epimaslinic acid (9): 472 [M]⁺ (4), 248 (100), 235

Table 2 NMR data of the compound 5 in CDCl₃

Carbon number	DEPT	HSQC		HMBC
		¹ H-NMR δ(ppm)	¹³ C-NMR δ(ppm)	
1	CH ₂	1.20 (m, 1H)	35.77	
		2.72 (brd, J=13.0 Hz, 1H)		
2	CH ₂	1.58 (m, 1H)	18.80	C-10
		1.72 (dd, J=13.3,13.4 Hz, 1H)		
3	CH ₂	1.21 (m, 1H)	40.97	-
		1.47 (brd, J=12.7 Hz, 1H)		C-18, C-19
4	C	-	32.96	
5	CH	1.47 (brd, J=12.7 Hz, 1H)	46.12	C-4, C-7, C-10, C-18, C-20
6	CH ₂	1.60 (m, 1H)	24.61	C-5, C-10
		1.93 (d, J=14.9 Hz, 1H)		C-5, C-7, C-8, C-10
7	CH	5.92 (brs, 1H)	64.48	
8	C	-	139.45	
9	C	-	149.94	
10	C	-	39.06	
11	C	-	183.72	
12	C	-	150.75	
13	C	-	124.66	
14	C	-	185.45	
15	CH ₃	3.15 (m, 1H)	24.15	C-12, C-13, C-14, C-17
16	CH ₃	1.17 (d, J=7.0 Hz, 3H)	19.68	C-13, C-15, C-17
17	CH ₃	1.22 (d, J=7.0 Hz, 3H)	19.86	C-13, C-15, C-16
18	CH	0.87 (s, 3H)	21.61	C-3, C-5, C-19
19	CH ₃	0.87 (s, 3H)	32.96	C-3, C-5, C-18
20	CH ₃	1.23 (s, 3H)	18.48	C-1, C-5, C-9, C-10
1'	C	-	169.46	
2'	CH ₃	2.03 (s, 3H)	21.11	C-1'
OH-12		7.12 (s, 1H)	-	C-11, C-12, C-13

(9), 223 (12), 203 (54), 189 (15), 133 (28). coleonic acid (10): *m/z* 470 [M]⁺ (7), 452 (25), 264 (18), 206 (15), 201 (35), 159 (28), 146 (50), 105 (100).

β-sitosterol: ¹³C-NMR (125 MHz, CDCl₃): δ_C (from C-1 to C-29) 37.3, 31.7, 71.8, 42.3, 140.8, 121.7, 31.9, 31.9, 50.2, 36.5, 21.1, 39.8, 42.3, 56.8, 24.3, 28.3, 56.1, 11.9, 19.8, 36.2, 18.8, 34.0, 26.1, 45.8, 29.2, 19.0, 19.4, 23.1, 12.0.

Stigmasterol: ¹³C-NMR (125 MHz, CDCl₃): δ_C (from C-1 to C-29) 37.3, 31.7, 71.8, 42.2, 140.8, 121.7, 31.9, 31.9, 50.2, 36.4, 21.1, 39.7, 42.2, 56.9, 24.4, 28.9, 56.0, 12.0, 19.4, 40.5, 21.2, 138.3, 129.3, 51.6, 31.9, 19.0, 21.1, 25.4, 12.2.

Discussion

Literature reviews show that *Salvia* species are important medicinal and food plants. About 200 triterpenoids have been isolated and identified from about 100 *Salvia* species and presented in a review article by Topcu [29]. The oleanane, and ursane triterpenes display various pharmacological activities. These triterpenes can be

considered as the lead compounds for the development of new multi-targeting bioactive agents [30]. Both oleanolic and ursolic acid have been documented to protect liver against chemically induced injuries in laboratory animals *via* inhibition of toxicant activation and enhancement of immune systems. These two triterpenes have also been long-recognized as anti-inflammatory and anti-hyperlipidemic agents. Furthermore, anti-tumor activity has been noted from both non-toxic compounds [31].

Corosolic acid, a triterpenoid compound has been proved to have anti-diabetic effects on animal and human *via* enhancing glucose uptake in L6 myotubes and facilitating glucose transporters isoform 4 translocation in CHO/hIR cells. In addition, corosolic acid has been reported to inhibit the enzymatic activity of several non-receptor protein tyrosine phosphatases (PTPs) [32]. The abietane diterpene 7 α-acetoxy-royleanone, containing quinone moiety in its structure, was demonstrated to possess cytotoxic activity on cancer cell lines and also alkylating properties using the nucleophile

Table 3 ^{13}C -NMR data of the compounds 6–10

Carbon Number	8 ^a	9 ^a	10 ^b	Carbon Number	8	9	10
1	41.94	41.69	61.4	16	24.13	23.27	27.3
2	66.49	66.50	156.1	17	48.10	46.48	-
3	78.91	78.92	135.2	18	52.63	41.04	55.3
4	38.34	38.34	42.7	19	39.04	45.89	73.5
5	48.13	48.14	64.4	20	38.84	30.67	44.4
6	18.03	18.03	18.3	21	30.61	33.83	26.6
7	32.73	32.46	35.3	22	36.70	32.46	39.0
8	39.49	39.70	42.9	23	28.48	28.48	30.3
9	47.28	47.35	43.1	24	21.81	21.79	21.9
10	38.23	38.42	51.8	25	16.47	16.33	19.1
11	23.27	22.95	27.1	26	16.98	17.13	16.5
12	125.64	122.46	129.5	27	23.74	26.07	25.5
13	138.06	143.68	140.3	28	181.95	181.95	182.2
14	42.10	41.76	43.3	29	17.10	33.05	27.7
15	27.96	27.63	29.9	30	21.16	23.58	16.5

^a In CDCl_3 .

^b In CD_3OD .

4-(4-nitrobenzyl) pyridine [33]. Among the reported antimicrobial labdane-type diterpenes, manool is the most active, since it furnished very promising MIC values for several tested bacteria that are closely associated with periodontitis [34].

According to chemotaxonomic significance, the isolated terpenes (manool (4), 7α -acetoxy-royleanone (5), ursolic acid (6), oleanolic acid (7), 3-epimaslinic acid (9)) were previously reported from other *Salvia* species such as *S. sclarea* [21], *S. pubescens* [35], *S. lavandulifolia* [36] and *S. officinalis* [37]. To the best of our knowledge, there is no report about the presence of the above mentioned compounds from *S. hypoleuca*. The triterpene 3-epicorosolic acid (8) and coleonolic acid (10) has not been reported from *Salvia* species, while some other

genus of Lamiaceae such as *Perilla frutescens* [38] and *Coleus forskohlii* [39] contains these triterpenes.

Conclusions

In conclusion, the results of this study indicated the presence of ten terpenes and sterols in the root extract of *S. hypoleuca* as: sitosterol oleate (1), β -sitosterol (2), stigmasterol (3), manool (4), 7α -acetoxy royleanone (5), ursolic acid (6), oleanolic acid (7), 3-epicorosolic acid (8), 3-epimaslinic acid (9) and coleonolic acid (10). Some of the isolated compounds (1–7, 9) have not been previously reported from *S. hypoleuca* and the triterpenes 8 and 10 not reported from *Salvia* genus until now. The above mentioned compounds have been recognized as

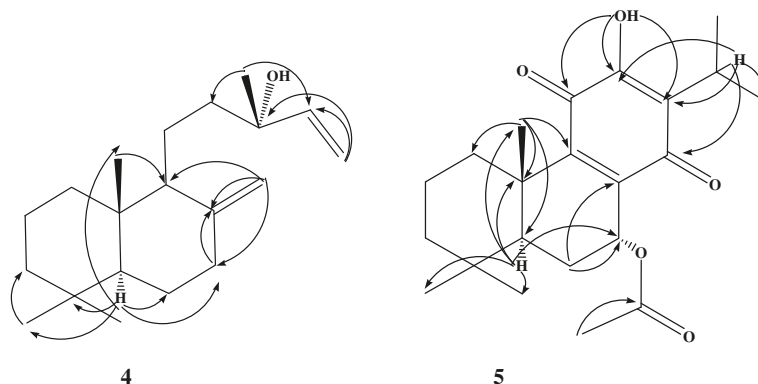


Figure 2 HMBC correlations and important assignments of the compounds 4 and 5 (H→C).

the biologically and pharmacologically active constituents from this medicinal and aromatic species of *salvia*.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

SS carried out the interpretation of the NMR data and identification of the compounds. MG carried out the isolation and purification process. ARG participated in design of the study, helped in structured elucidation and final approved of the version to be published. AS participated in drafting the manuscript and helped in isolation of the compounds. All authors read and approved the final manuscript.

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References

- Hedge IC: *Labiatae*. In *Flora Iranica. Volume 151*. Edited by Rechinger KH. Graz: Akademische Druck-u Verlagsanstalt; 1986:403-480.
- Saeidnia S, Gohari AR, Malmir M, Moradi-Afrapoli F, Ajani Y: **Tryptophan and sterols from *Salvia limbata***. *J Med Plants* 2011, **10**:41-47.
- Lu Y, Foo LY: **Polyphenolics of *Salvia* - a review**. *Phytochemistry* 2002, **59**:117-140.
- Tutin TG, Heywood VH, Burgess NA, Moore DM, Valentine DH, Walters SM, Webb DA: ***Salvia* L.** In *Flora Europa*. Edited by Hedge IC. Cambridge: Cambridge University Press; 1972:188-192.
- Ulubelen A, Sönmez U, Topcu G, Johansson CB: **An abietane diterpene and two phenolics from *Salvia forskahlei***. *Phytochemistry* 1996, **42**:145-147.
- Gohari AR, Saeidnia S, Malmir M, Hadjiakhoondi A, Ajani Y: **Flavones and rosmarinic acid from *Salvia limbata***. *Nat Prod Res* 2010, **24**:1902-1906.
- Suzuki H, Sawada S, Watanabe K, Nagae S, Yamaguchi MA, Nakayama T, Nishino T: **Identification and characterization of a novel anthocyanin malonyltransferase from scarlet sage (*Salvia splendens*) flowers: an enzyme that is phylogenetically separated from other anthocyanin acyltransferases**. *Plant J* 2004, **38**:994-1003.
- Amiri H: **Quantative and qualative changes of essential oil of *Salvia bracteata* Bank et Sol. in different growth stages**. *Daru* 2007, **15**(Suppl 2):79-82.
- Sajjadi SE, Shahpiri Z: **Chemical composition of the essential oil *Salvia Limbata* C.A. mey**. *Daru* 2004, **12**(Suppl 3):94-97.
- Ghannadi A, Samsam-shariat SH, Moattar F: **Volatile constituents of the flower of *Salvia hydrangea* DC. Ex Benth**. *Daru* 1999, **7**(Suppl 3):23-25.
- Matloubi moghadam F, Amin GH, Safavi poorsohi E: **Composition of stem bark essential oil from *Salvia macrosiphon* Boiss**. *Daru* 2000, **8**(Suppl 1):28-29.
- Rustaiyan A, Koussari S: **Further sesterterpenes from *Salvia hypoleuca***. *Phytochemistry* 1988, **27**:1767-1769.
- Rustaiyan A, Niknejad A, Nazarians L, Jakupovic J, Bohlmann F: **Sesterterpenes from *Salvia hypoleuca***. *Phytochemistry* 1982, **21**:1812-1813.
- Ali MS, Ahmed W, Jassbi AR, Onocha PA: **Hypoleuenic acid: a trans-cinnamic acid derived secondary metabolite from *Salvia hypoleuca* (Lamiaceae)**. *J Chem Soc Pak* 2005, **27**:316-319.
- Bigdeli M, Rustaiyan A, Nadimi M, Masoudi S: **Composition of the essential oil from roots of *Salvia hypoleuca* Benth. from Iran**. *J Essent Oil Res* 2005, **17**:82-83.
- Rustaiyan A, Komeilizadeh H, Masoudiand S, Monfared A: **Volatile constituents of three *Salvia* species grown wild in Iran**. *Flav Frag J* 1999, **14**:276-278.
- Atta-ur-Rahman: **Studies in natural products chemistry**. *Elsevier B V* 2008, **35**:753.
- Julien-David D, Geoffroy P, Marchioni E, Raul F, Aoude-Werner D, Miesch M: **Synthesis of highly pure (oxy) phytosterols and (oxy) phytosterol esters Part II. (Oxy)-sitosterol esters derived from oleic acid and from 9,10-dihydroxystearic acid**. *Steroids* 2008, **73**:1098-1109.
- Gohari AR, Saeidnia S, Shahverdi AR, Yassa N, Malmir M, Mollazade K, Naghinejad AR: **Phytochemistry and antimicrobial compounds of *Hymenocrater calycinus***. *Eur Asia J Bio Sci* 2009, **3**:64-68.
- Nasiri M, Saeidnia S, Mashinchian-Moradi A, Gohari AR: **Sterols from the red algae, *Gracilaria salicornia* and *Hypnea flagelliformis*, from Persian Gulf**. *Phcog Mag* 2011, **7**:97-100.
- Ulubelen A, Topcu G, Eris C, Sonmez U, Kartal M, Kurucu S, Bozok-Johansson C: **Terpenoids from *Salvia sclarea***. *Phytochemistry* 1994, **36**:971-974.
- Rodriguez B: **¹H and ¹³C NMR spectral assignments of some natural abietane diterpenoids**. *Mag Res Chem* 2003, **41**:741-746.
- Gohari AR, Saeidnia S, Hadjiakhoondi A, Abdoullahi M, Nezafati M: **Isolation and Quantificative Analysis of Oleanolic acid from *Satureja mutica* Fisch. & C. A. Mey**. *J Med Plants* 2009, **8**:65-6934.
- Kojima H, Ogura H: **Configurational Studies on Hydroxy Groups at C-2,3 and 23 or 24 of Oleanene and Ursene-type Triterpenes by NMR Spectroscopy**. *Phytochemistry* 1989, **28**:1703-1710.
- Mahato SB, Kundu AP: **¹³C NMR Spectra of pentacyclic triterpenoids, a compilation and some salient features**. *Phytochemistry* 1994, **37**:1517-1575.
- Raja Rao KV, Rao LJM, Prakasa Rao NS: **An A-Ring Contracted Triterpenoid from *Hyptis suaveolens***. *Phytochemistry* 1990, **29**:1326-1329.
- Shahani S, Monsef-Esfahani HR, Saeidnia S, Saniee P, Siavoshi F, Foroumadi A, Samadi N, Gohari AR: **Anti-Helicobacter pylori activity of the methanolic extract of *Geum iranicum* and its main compounds**. *Z Naturforsch* 2012, **67c**:172-180.
- Gohari AR, Hadjiakhoondi A, Sadat-Ebrahimi SE, Saeidnia S, Shafiee A: **Cytotoxic triterpenoids from *Satureja macrantha* C.A. Mey**. *Daru* 2005, **13**(4):177-181.
- Topcu G: **Bioactive triterpenoids from *Salvia* species**. *J Nat Prod* 2006, **69**:482-487.
- Jager S, Trojan H, Kopp T, Laszczyk MN, Scheffler A: **Pentacyclic triterpen distribution in various plants-rich sources for a new group of multi-potent plant extracts**. *Molecules* 2009, **14**:2016-2031.
- Liu J: **Pharmacology of oleanolic acid and ursolic acid**. *J Ethnopharmacol* 1995, **49**:57-68.
- Shi L, Zhang W, Zhou YY, Zhang YN, Li JY, Hu LH, Li J: **Corosolic acid stimulates glucose uptake via enhancing insulin receptor phosphorylation**. *Eur J Pharmacol* 2008, **584**:21-29.
- Fronza M, Lamy E, Günther S, Heinzmann B, Laufer S, Merfort I: **Abietane diterpenes induce cytotoxic effects in human pancreatic cancer cell line MIA PaCa-2 through different modes of action**. *Phytochemistry* 2012, **78**:107-119.
- Souza AB, de Souza MGM, Moreira MA, Moreira MR, Furtado NAJC, Martins CHG, Bastos JK, dos Santos RA, Heleno VCG, Ambrosio SR, Veneziani RCS: **Antimicrobial evaluation of diterpenes from *Copaifera langsdorffii* oleoresin against periodontal anaerobic bacteria**. *Molecules* 2011, **16**:9611-9619.
- Galicía MA, Esquivel B, Sanchez AA, Cardenas J, Ramamoorthy TP, Rodriguez-Hahn L: **Abietane diterpenoids from *Salvia pubescens***. *Phytochemistry* 1988, **27**:217-219.
- Passannantia S, Paternostroa M, Piozzi F: **Triterpene acids from *Salvia* and *Teucrium* species**. *Phytochemistry* 1983, **22**:1044-1045.
- Brieskorn CH, Kapadia Z: **Bestandteile von *Salvia officinalis***. *Planta Med* 1980, **38**:86-90.
- Banno N, Akihisa T, Tokuda H, Yasukawa K, Higashihara H, Ukiya M, Watanabe K, Kimura Y, Hasegawa J, Nishino H: **Triterpene acids from the leaves of *Perilla frutescens* and their anti-inflammatory and antitumor-promoting effects**. *Biosci Biotech Biochem* 2004, **68**:85-90.
- Roy R, Vishwakarma RA, Varma N, Tandon JS: **Coleonolic acid, a rearranged ursane triterpenoid from *Coleus forskohlii***. *Tetrahedron Lett* 1990, **31**:3467-3470.

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